Proposed New BACT Guidelines for Distributed Generation

Martin L. Kay and Howard B. Lange

Presented to South Coast Air Quality Management District
BACT Scientific Review Committee
March 25, 2004

Background

A distributed generation (DG) power plant is a stationary, non-emergency electricity generation plant that produces power primarily for use within the facility in which it is sited and/or another facility(ies) with which it has a direct energy interconnection(s). DG power plants are thus differentiated from merchant power plants, which sell power to the grid.

DG projects, other than those utilizing digester or landfill gas, are restricted by AQMD's Clean Fuels Policy (in the BACT Guidelines) in their choice of fuels, and virtually all are fueled on natural gas. Essentially all DG plants utilize I.C. engine or gas turbine technology, and new DG plants are expected to continue to employ these technologies at least in the foreseeable future. Longer term, cleaner technologies such as fuel cells may begin to be utilized as they continue to be developed and become more cost competitive. These technologies have electrical efficiencies ranging from approximately 20% to 40%, with the balance of the fuel heating value appearing as waste heat. DG projects are generally not economically justified unless part of the waste heat can be utilized by the host facility(ies), and these projects are almost always configured as "cogeneration" or "combined heat and power (CHP)" projects.

Current Status of BACT for DG Projects

DG power plants tend to be much smaller than merchant or central station power plants since they are limited in size to the power demand of the facilities that they serve. Many DG power plants have capacities <1 MW to a few MW, and few are larger than 25 MW. Many DG projects will occur in non-major polluting facilities and will themselves be non-major; and thus criteria pollutant constraints on many of these projects will consist of AQMD's Minor Source BACT (MSBACT) guidelines for gas turbines and I.C engines. MSBACT guidelines for gas turbines and I.C. engines applicable to DG projects are summarized in Tables 1 and 2. The guideline for I.C. engines rated at or above 2064 bhp shown in Table 2 includes an update that is presently being reviewed with the BACT Scientific Review Committee and is expected to take effect as of June 4, 2004.

Table 1. MSBACT Guidelines for Gas Turbines Applicable to DG Projects

10-20-2000 Rev. 0

Equipment or Process: Gas Turbine

	Criteria Pollutants					
Subcategory/ Rating/Size	**VOC**	**NOx**	**SOx**	**CO**	**PM_{10}**	**Inorganic**
Natural Gas Fired, < 3 MWe		9 ppmvd @ 15% O_2 (10-20-2000)		10 ppmvd @ 15% O_2 (10-20-2000)		9 ppmvd ammonia @ 15% O_2 (10-20-2000)
Natural Gas Fired, ≥ 3 MWe and < 50 MWe		2.5 ppmvd @ 15% O_2 x $\frac{\text{efficiency (\%)}}{34\%}$ (6-12-98)		10 ppmvd @ 15% O_2 (6-12-98)		5.0 ppmvd ammonia @ 15% O_2 (10-20-2000)

Table 2. MSBACT Guidelines for I.C. Engines Applicable to DG Projects

10-20-2000 Rev. 0
6-4-2003 Rev. 1

Equipment or Process: I.C. Engine, Stationary

	Criteria Pollutants					
Subcategory/ Rating/Size	**VOC**	**NOx**	**SOx**	**CO**	**PM_{10}**	**Inorganic**
Non-Emergency, < 2064 bhp	0.15 grams/bhp-hr (4-10-98)	0.15 grams/bhp-hr (4-10-98)	See Clean Fuels Policy in Part C of the BACT Guidelines (10-20-2000)	0.60 grams/bhp-hr (4-10-98)	See Clean Fuels Policy in Part C of the BACT Guidelines (10-20-2000)	
Non-Emergency, ≥ 2064 bhp	25 ppmvd @ 15% O_2 (6-4-2004)	9 ppmvd @ 15% O_2 (6-4-2004)	Same as Above (10-20-2000)	33 ppmvd @ 15% O_2 (5-8-98)	0.045 grams/bhp-hr (5-8-98)	Ammonia: 10 ppmvd @ 15% O_2 (6-4-2004)

CARB Certification Program for DG Equipment Not Requiring District Permits

SB1298, chaptered into law in September 2000 by the California state legislature, recognized that distributed generation that is exempt from district permits could have significantly higher emissions than the extremely low emissions of new central station power plants. Therefore it required the California Air Resources Board (CARB) to institute a certification program for DG technologies to be applied to cases that are exempt from district permits. Furthermore, it required that as soon as practicable, certified DG meet emission standards (expressed as pounds per megawatt-hour[MW-hr] produced) equivalent to the best available control technology for permitted central station power plants in California.

CARB's DG certification program (Ref. 1) pursuant to this order took effect January 1, 2003. Table 3 summarizes the emission standards that are required by this program.

Table 3. Summary of DG Emission Standards Required by CARB Certification Program

	Effective 1/1/2003 lb/MW-hr		Effective 1/1/2007 lb/MW-hr
	w/o CHP	w/ CHP	
NOx	0.5	0.7	.07*
CO	6.0	6.0	0.1*
VOC	1.0	1.0	.02*
PM	Clean Fuel**	Clean Fuel**	Clean Fuel**

*Allows CHP credit of 1 MW-hr per 3.4 MMBtu waste heat recovered.

**Equivalent to natural gas with maximum sulfur content of 1 gr/100scf.

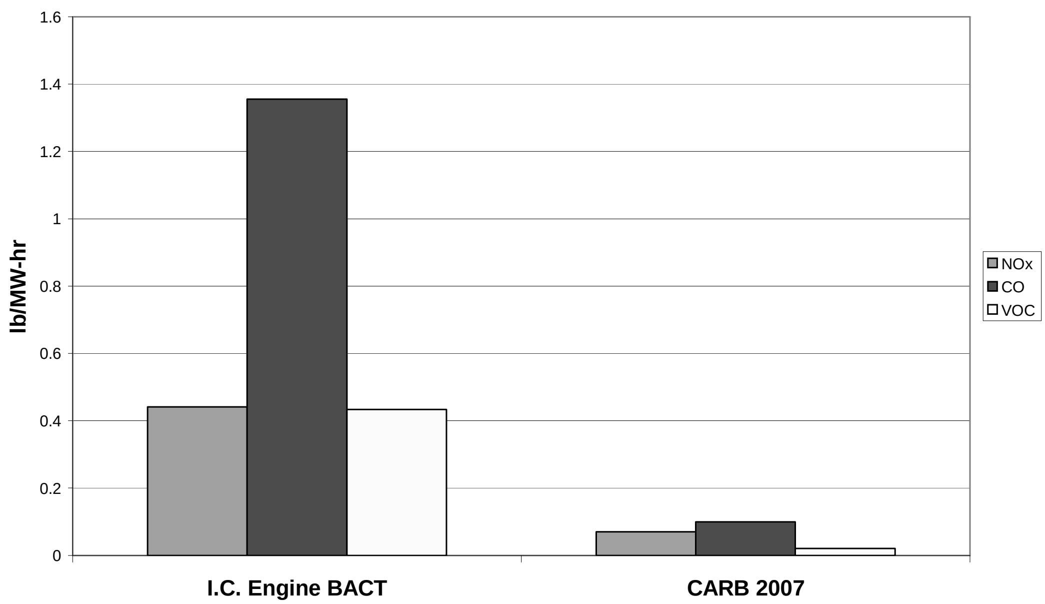
The 2007 standards are equivalent to emission standards applied to new central station power plants in California.

CARB has certified two fuel cells to meet the 2007 standards and two microturbines to meet the 2003 standards. Only these four DG technologies, and any zero-emission DG technology such as wind and solar power may be sold in California, unless the DG is large enough to require a district permit.

Possibility of Implementing CARB's 2007 Standards as BACT

CARB's 2003 certification standards are essentially equivalent to or less stringent than AQMD's current BACT guidelines that are applicable to DG equipment (Tables 1 and 2). However, CARB's 2007 standards are significantly more stringent. The current BACT requirements for most DG permitted by AQMD result in emissions that are from 7 to 50 times higher than the emissions allowed from new large central station power plants. Figure 1 demonstrates the differences. Also, whereas large central station power plants are required by AQMD's New Source Review program to provide emission offsets for all emission increases to mitigate emission impacts, most DG units are exempt from emission offset requirements. In addition, large central station power plants are required to have continuous emission monitor systems (CEMS) for NOx and CO and to report exceedances to AQMD whereas most DG units are not required to have CEMS. Therefore, DG excedances may go undiscovered.

Figure 1. Current BACT for DG (I.C. Engine) versus CARB's 2007 DG Standards



Since CARB's 2007 standards will be applicable only to equipment not requiring permits, in AQMD's jurisdiction, only gas turbines rated at ≤2.975 MMBtu/hr input and I.C. engines rated at ≤50 bhp will be affected (Ref. 3). AQMD is therefore interested in the possibility of requiring that larger DG equipment, which need permits, also meet those standards. Furthermore, AQMD believes that DG technologies already exist that can meet the 2007 standards. Therefore, AQMD management asked the BACT Team to evaluate the possibility of implementing CARB's 2007 standards, or similar standards, in the BACT Guidelines.

The DG technologies that AQMD believes can meet CARB's 2007 emission standards are:

- Kawasaki GPB15X Gas Turbine--1.5 MW, guaranteed emission limits of 2.5 ppm NOx, 6 ppm CO and 2 ppm VOC, all dry basis, corrected to 15% O2, down to 70% of rated load. These emission limits together with heat input of 20.7 MMBtu/hr (LHV) and 53.7% waste heat recovery specified by the manufacturer meet the CARB 2007 standards.
- Fuel Cells--available in increments as small as 10 kW, emissions are equal to or less than the CARB 2007 standards (Ref. 2).
- Large combustion gas turbines with combined heat and power (CHP). These are very similar to the central station combined-cycle power plants that are the basis of the 2007 standards.

<u>Requirements of Health & Safety Code in Amending MSBACT</u>

California Health & Safety Code section 40440.11 requires that AQMD, in amending MSBACT to be more stringent, show that the proposed new MSBACT is based on a technology that has been successfully practiced for at least a year and is cost effective based on established cost effectiveness criteria. Cost effectiveness must be demonstrated on both an "average" and an "incremental" basis. Average cost effectiveness compares the low-emission technology to the uncontrolled case, and incremental cost effectiveness compares the low-emission technology to the next most stringent degree of control.

Commercial and Technical Status of the Low-Emission DG Technologies

The Kawasaki gas turbine employs a retrofitted catalytic combustion module to achieve low NOx emissions while maintaining low emissions of CO and VOC. The first commercial use of the Kawasaki gas turbine was at the Silicon Valley Power plant in Santa Clara, CA, where it was started up in December 1998 and has been in regular use. That unit has undergone several modifications over the years mainly to improve its emissions performance. During the second half or 1999, the catalyst developer conducted emissions monitoring for six months pursuant to a CARB technology verification program, and CARB verified the technology not to exceed 2.5 ppm and 6 ppm CO (dry, 15% O2) when operating at or above 98% of rated capacity. Additional emissions monitoring was conducted under CEC's PIER program, and the results of that monitoring, which covered three phases of hardware modifications, are summarized in Table 4. The history of operation at the Silicon Valley Power plant together with the emission monitoring performed for CARB and CEC establish that the technology has been practiced for more than a year and supports the capability of the technology to meet the guarantee offered by the manufacturer. Additional units have been sold, and two more are in operation.

Table 4. Summary of Kawasaki Gas Turbine Emissions
Documented for CEC PIER Program

	PPMVD@15%O2, Avg./Max.		
	NOx	CO	VOC
Phase I June-December 1999	1.3/2.8	1.2/9.6	1.0/8.8
Phase II April-August 2000	1.2/1.7	0.5/25.9	0.6/3.5
Phase III May-June 2001	1.1/1.5	0.4/5.5	0.4/3.0

There are a number of developing fuel cell-based electricity generation technologies, all of which have very low emission characteristics. Several companies offer fuel cell systems that can be used in DG applications. Although virtually all sales of such systems to date have been for demonstration purposes and have been funded partially or totally by government agencies, there are a number of installations that have operated for more than a year.

Cost Effectiveness Analysis

A cost effectiveness analysis was performed to evaluate use of the Kawasaki gas turbine or a fuel cell system for a DG project as a means of reducing emissions relative to technologies that are normally used. The calculation spreadsheet is presented in Attachment A.

The base case for the analysis was considered to be the use of an I.C. engine, which is the lowest cost DG option and the most common. Since it was evident that the Kawasaki gas turbine would be more cost effective than fuel cell technology, the analysis considered only the Kawasaki gas turbine as the low-emission technology for DG capacity ≥1.5 MW. For smaller systems, the analysis considered a fuel cell system as the low-emission technology.

Calculations were done for three DG project sizes: 0.5 MW, 1.5 MW and 3 MW. For purposes of the incremental cost effectiveness analysis, the next most stringent degree of control in each case was considered to be the control technology that underlies the MSBACT guideline for that engine size (Table 2). These control technologies consist of a rich-burn engine with a three-way catalyst for the smaller engines (0.5 and 1.5 MW project sizes) and an SCR system with an oxidation catalyst for the larger engine (3 MW project size).

As can be seen in Attachment A, the Kawasaki gas turbine was found to be cost effective on both an average and an incremental basis for both project sizes considered. Fuel cell technology, on the other hand, while found to be cost effective on an average basis, was found to be not cost effective on an incremental basis. Therefore, the amending MSBACT is justified for project sizes of 1.5 MW and above but not for smaller project sizes.

Proposed MSBACT Amendment

The proposed amendment to MSBACT for DG projects is shown in Attachment B. It is proposed that a new equipment category entitled "Distributed Generation" be created to encompass all DG projects ≥1.5 MW, regardless of the DG technology that is chosen by the applicant. The guideline will require that the project meet the CARB 2007 standards for NOx, CO and VOC. AQMD's Clean Fuels Policy will be referenced as the guideline for SOx and PM. Ammonia emission guidelines for gas turbines and I.C. engines will be referenced as the guideline for inorganic emissions. This would constrain ammonia emissions in case an applicant chooses to meet the CARB 2007 NOx limit by using SCR technology.

Since for a DG project an applicant normally selects either gas turbine or I.C. engine technology, the guidelines for those equipment categories will be modified to direct the applicant to the Distributed Generation category, as shown in Attachment B.

Proposed DG BACT Guidelines for Major Sources

BACT for major sources is based on federal Lowest Achieveable Emission Rate (LAER) (Ref. 4) and is not required to pass a cost-effectiveness test. Therefore, staff recommends that all new DG equipment at major sources be required henceforth to comply with the CARB 2007 standards as well. Major sources can use large combustion gas turbines with CHP, the smaller 1.5 MW Kawasaki gas turbine with CHP, equipment certified by CARB to meet the 2007 standards, or zero-emission technology such as solar or wind power.

References

1. California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 8, Article 3, Sections 9400-94214, www.arb.ca.gov/energy/dg/dg.htm.
2. Performance and Cost Trajectories of Clean Distributed Generation Technologies", Energy Nexus Group, May 2002
3. AQMD Rule 219, Equipment not Requiring a Written Permit Pursuant to Regulation II.
4. AQMD BACT Guidelines, Part A-Policies and Procedures for Major Polluting Facilities

Attachment A. Cost Effectiveness Analysis

Attachment B. Proposed MSBACT Amendment

Equipment or Process: Distributed Generation [1)]

	Criteria Pollutants					
Rating/Size	**VOC**	**NOx**	**SOx**	**CO**	**PM_{10}**	**Inorganic**
≥1.5 MW_e	.02 lb/MW-hr [2)] (6-4-2004)	.07 lb/MW-hr [2)] (6-4-2004)	See Clean Fuels Policy in Part C of the BACT Guidelines (6-4-2004)	0.1 lb/MW-hr [2)] (6-4-2004)	See Clean Fuels Policy in Part C of the BACT Guidelines (6-4-2004)	See Appropriate Guideline for Gas Turbine or Stationary I.C. Engine (6-4-2004)

1) Applies to any electricity generation project with one or more generation units having aggregate generation capacity ≥1.5 MW_e producing electricity primarily for use within the facility in which it is sited and/or another facility(ies) with which it has a direct energy interconnection(s). Does not include distributed generation where the primary fuel is digester or landfill gas.

2) Calculation of lb/MW-hr may consider both electrical generation and waste heat utilization (3.413 MMBtu of waste heat is equivalent to 1 MW-hr).

10-20-2000 Rev. 0
6-4-2004 Rev. 1

Equipment or Process: Gas Turbine

	Criteria Pollutants					
Subcategory/ Rating/Size	**VOC**	**NOx**	**SOx**	**CO**	**PM_{10}**	**Inorganic**
Distributed Generation $\geq$1.5 MW_e [1)]	See Distributed Generation Guideline (6-4-2004)					
Natural Gas Fired, < 3 MWe		9 ppmvd @ 15% O_2 (10-20-2000)		10 ppmvd @ 15% O_2 (10-20-2000)		9 ppmvd ammonia @ 15% O_2 (10-20-2000)
Natural Gas Fired, $\geq$ 3 MWe and < 50 MWe		2.5 ppmvd @ 15% O_2 x $\frac{\text{efficiency (\%)}}{34\%}$ (6-12-98)		10 ppmvd @ 15% O_2 (6-12-98)		5.0 ppmvd ammonia @ 15% O_2 (10-20-2000)
Natural Gas Fired, $\geq$ 50 MWe	2.0 ppmvd (as methane) @ 15% O_2, 1-hour avg. OR 0.0027 lbs/MMBtu (higher heating value) (10-20-2000)	2.5 ppmvd @ 15% O_2, 1-hour rolling avg. OR 2.0 ppmvd @ 15 %O_2, 3-hour rolling avg. x $\frac{\text{efficiency (\%)}}{34\%}$ (10-20-2000)		6.0 ppmvd @ 15% O_2, 3-hour rolling avg. (10-20-2000)		5.0 ppmvd ammonia @ 15% O_2 (10-20-2000)
Emergency		See Clean Fuels Policy in Part C of the BACT Guidelines (10-20-2000)	See Clean Fuels Policy in Part C of the BACT Guidelines (10-20-2000)		See Clean Fuels Policy in Part C of the BACT Guidelines (10-20-2000)	
Continued on next page						
Landfill or Digester Gas Fired		25 ppmv, dry, corrected to 15 %O_2 (1990)	Compliance with Rule 431.1 (10-20-2000)	130 ppmv, dry, corrected to 15 %O_2 (10-20-2000)	Fuel Gas Treatment for Particulate Removal	

					(1990)	

1) Applies to any electricity generation project with one or more generation units having aggregate generation capacity ≥1.5 MW_e producing electricity primarily for use within the facility in which it is sited and/or another facility(ies) with which it has a direct energy interconnection(s). Does not include distributed generation where the primary fuel is digester or landfill gas.

10-20-2000 Rev. 0
6-4-2003 Rev. 1
6-4-2004 Rev. 2

Equipment or Process: I.C. Engine, Stationary

	Criteria Pollutants					
Subcategory/ Rating/Size	**VOC**	**NOx**	**SOx**	**CO**	**PM_{10}**	**Inorganic**
Distributed Generation ≥1.5 MW_e [1)]	See Distributed Generation Guideline (6-4-2004)					
Emergency[2)], Compression-ignition[3)]	1.0 grams/bhp-hr (4-10-98) See Table 1 for Tier 2 limits and schedule. (6-6-2003)	6.9 grams/bhp-hr (4-10-98) See Table 1 for Tier 2 limits and schedule. (6-6-2003)	Diesel Fuel Sulfur Content ≤ 0.05% by Weight (4-10-98) On or after June 1, 2004 the user may only purchase diesel fuel with a sulfur content no greater than 0.0015% by weight (Rule 431.2). (6-6-2003)	8.5 grams/bhp-hr (4-10-98) See Table 1 for Tier 2 limits and schedule. (6-6-2003)	0.38 grams/bhp-hr (4-10-98) See Table 1 for Tier 2 limits and schedule. (6-6-2003)	
Emergency[2)], Spark Ignition[4)]	1.5 grams/bhp-hr (10-20-2000)	1.5 grams/bhp-hr (10-20-2000)	See Clean Fuels Policy in Part C of the BACT Guidelines (10-20-2000)	2.0 grams/bhp-hr (10-20-2000)	See Clean Fuels Policy in Part C of the BACT Guidelines (10-20-2000)	
Landfill or Digester Gas Fired	0.8 grams/bhp-hr (4-10-98)	0.60 grams/bhp-hr (4-10-98)	Compliance with Rule 431.1 (10-20-2000)	2.5 grams/bhp-hr (4-10-98)		
Non-Emergency, < 2064 bhp	0.15 grams/bhp-hr (4-10-98)	0.15 grams/bhp-hr (4-10-98)	See Clean Fuels Policy in Part C of the BACT Guidelines (10-20-2000)	0.60 grams/bhp-hr (4-10-98)	See Clean Fuels Policy in Part C of the BACT Guidelines (10-20-2000)	

Non-Emergency, ≥ 2064 bhp	25 ppmvd @ 15% O_2 (6-4-2004)	9 ppmvd @ 15% O_2 (6-4-2004)	Same as Above (10-20-2000)	33 ppmvd @ 15% O_2 (5-8-98)	0.045 grams/bhp-hr (5-8-98)	Ammonia: 10 ppmvd @ 15% O_2 (6-4-2004)

1) Applies to any electricity generation project with one or more generation units having aggregate generation capacity ≥1.5 MW_e producing electricity primarily for use within the facility in which it is sited and/or another facility(ies) with which it has a direct energy interconnection(s). Does not include distributed generation where the primary fuel is digester or landfill gas.

2) An emergency engine is an engine which operates as a temporary replacement for primary mechanical or electrical power sources during periods of fuel or energy shortage or while a primary power source is under repair. This includes fire pumps, emergency electrical generation and other emergency uses. Exceptions to the requirements in Table 1 may be made for emergency fire pumps if it is demonstrated that there are no UL-listed fire pumps that meet the Tier 2 emission limits.

3) AQMD restricts operation of emergency compression-ignition engines to 50 hours per year for maintenance and testing and a maximum of 200 hours per year total operation. For engines used to drive standby generators, operation beyond 50 hours per year for maintenance and testing is allowed only in the event of a loss of grid power or up to 30 minutes prior to a rotating outage provided that the electrical grid operator or electric utility has ordered rotating outages in the control area where the engine is located or has indicated that it expects to issue such an order at a certain time, and the engine is located in a utility service block that is subject to the rotating outage.

4) AQMD restricts operation of emergency spark-ignition engines to 50 hours per year for maintenance and testing and a maximum of 200 hours per year total operation. For emergency spark-ignition engines used to drive standby generators, operation beyond 50 hours per year for maintenance and testing is allowed only during emergencies resulting in an interruption of service of the primary power supply or during Stage II or III electrical emergencies declared by the electrical grid operator. Operators are allowed to use emergency spark-ignition engines as part of an interruptible electric service program. An interruptible electric service program is a program in which the facility receives payment or reduced rates in return for a requirement to reduce its electric load on the grid when requested to do so by the utility, the grid operator, or other organization.